WHAT IS CLAIMED IS:

1. A method of producing a semi-solid material without stirring, comprising:

heating a metal alloy to form a metallic melt;

transferring an amount of the metallic melt into a vessel;

nucleating the metallic melt by regulating the transfer of the metallic melt into the vessel; and

crystallizing the metallic melt in the vessel by cooling the metallic melt at a controlled rate to form a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix.

2. The method of claim 1, wherein the controlled rate of cooling of the metallic melt is within a range of about 0.01 degrees Celsius per second to about 5.0 degrees Celsius per second.

3. The method of claim 2, wherein the controlled rate of cooling of the metallic melt is within a range of about 0.01 degrees Celsius per second to about 1.0 degree Celsius per second.

4. The method of claim 2, wherein the controlled rate of cooling is at least partially controlled by adding heat to the vessel.

5. The method of claim 1, wherein the regulating includes transferring the metallic melt into the vessel at a selected transfer temperature.

6. The method of claim 5, wherein the selected transfer temperature is between the coherency temperature of the metal alloy and about 25 degrees Celsius above the liquidus temperature of the metal alloy.

7. The method of claim 6, wherein the selected transfer temperature is between about 3 degrees Celsius above the liquidus temperature of the metal alloy and about 15 degrees Celsius above the liquidus temperature of the metal alloy.

8. The method of claim 5, wherein the regulating further includes transferring the metallic melt into the vessel at a selected vessel temperature.

9. The method of claim 8, wherein the selected vessel temperature is between about 606 degrees Celsius and about 610 degrees Celsius.

10. The method of claim 5, further comprising:

holding the metallic melt in an intermediate vessel prior to the transferring; and

controllably adjusting the temperature of the metallic melt in the intermediate vessel to the selected transfer temperature.

11. The method of claim 1, wherein the regulating further includes transferring the metallic melt into the vessel at a selected rate of transfer.

12. The method of claim 11, wherein the selected rate of transfer is between about 0.01 pounds per second and about 1.0 pounds per second.

13. The method of claim 12, wherein the selected rate of transfer is about 0.50 pounds per second.

14. The method of claim 11, wherein the regulating further includes transferring a select amount of the metallic melt into the vessel.

15. The method of claim 14, wherein the select amount is between about 0.50 pounds and about 10 pounds.

16. The method of claim 1, wherein the regulating includes controlling a differential between the temperature of the metallic melt during the heating and the temperature of the metallic melt during the transferring.

17. The method of claim 16, wherein the regulating includes controlling a drop in temperature of the metallic melt during the transferring of the metallic melt into the vessel.

18. The method of claim 1, wherein the metal alloy is heated to a temperature no greater than 40 degrees Celsius above the liquidus temperature of the metal alloy to form the metallic melt.

19. The method of claim 1, wherein the rounded solid particles are partially dendritic.

20. The method of claim 20, wherein the rounded solid particles have a diameter in a range between about 40 μm and about 50 μm.

21. The method of claim 1, wherein the semi-solid material is produced without stirring the metallic melt.

22. The method of claim 21, wherein the semi-solid material is produced without agitating the metallic melt.

23. The method of claim 1, wherein the nucleating and crystallizing occur without the use of a grain refiner.

24. The method of claim 1, wherein the vessel is a shot sleeve of a semi-solid forming press.

25. The method of claim 24, further comprising:

injecting the semi-solid material from the shot sleeve directly into a die mold; and

forming the semi-solid material into a shaped part.

26. The method of claim 25, wherein the shot sleeve includes:

a passage for receiving the semi-solid material; and

a ram displaceable along the passage; and

wherein the method further comprises injecting the semi-solid material into the die mold at a controlled rate by regulating displacement of the ram along the passage.

27. An apparatus for producing semi-solid material without stirring, comprising:

means for heating a metal alloy to a molten state;

a semi-solid forming press including a shot sleeve;

means for transferring an amount of said molten alloy into said shot sleeve; and

means for controlling the cooling rate of the molten alloy in said shot sleeve within a range of about 0.01 to 5.0 degrees Celsius per second to form a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix.

28. The apparatus of claim 27, wherein the cooling rate of the molten alloy is within a range of about 0.01 degrees Celsius per second to about 1.0 degree Celsius per second.

29. The apparatus of claim 27, further comprising means for regulating the transfer of said molten alloy into said shot sleeve to nucleate said molten alloy.

30. The apparatus of claim 27, further comprising means for injecting the semi-solid material from the shot sleeve directly into a mold to produce a shaped part.

31. The apparatus of claim 27, further comprising means for adjusting the temperature of said molten alloy prior to being transferred into said shot sleeve.

32. The apparatus of claim 27, wherein said means for controlling includes means for heating said shot sleeve to at least partially control said cooling rate of said molten alloy.

33. An apparatus for producing semi-solid material without stirring, comprising:

a furnace adapted to heat a metal alloy to form a metallic melt; and

a temperature-controlled vessel extending along an axis and being adapted to receive an amount of said metallic melt and to cool said metallic melt at a controlled rate to cause said metallic melt to form a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix, said temperature-controlled vessel having a plurality of heat transfer zones, each of said plurality of heat transfer zones being adapted to independently control the temperature of the metallic melt disposed adjacent thereto.

34. The apparatus of claim 33, wherein said temperature-controlled vessel includes a sidewall, one of said heat transfer zones being adapted to control the temperature of the metallic melt disposed adjacent a first axial portion of said sidewall, another of said heat transfer zones being adapted to control the temperature of the metallic melt disposed adjacent a second axial portion of said sidewall.

35. The apparatus of claim 34, wherein said sidewall includes a number of passageways adapted to carry a heat transfer media, said heat transfer media flowing

through said number of passageways in said sidewall to effectuate heat transfer between said heat transfer media and said metallic melt.

36. The apparatus of claim 35, wherein said heat transfer media is oil.

37. The apparatus of claim 35, wherein said heat transfer media is air.

38. The apparatus of claim 34, wherein said first axial portion extends along approximately one-third of said sidewall, and wherein said second axial portion extends along approximately two-thirds of said sidewall.

39. The apparatus of claim 34, wherein said temperature-controlled vessel further comprises an end wall, another of said heat transfer zones being adapted to control the temperature of the metallic melt disposed adjacent said end wall.

40. The apparatus of claim 39, wherein each of said sidewall and said end wall includes a number of passageways adapted to carry a heat transfer media, said heat transfer media flowing through said number of passageways in said sidewall and said end wall to effectuate heat transfer between said heat transfer media and said metallic melt.

41. The apparatus of claim 40, wherein said temperature-controlled vessel further comprises:

an open end positioned generally opposite said end wall and adapted to receive said metallic melt; and

an end cap positioned adjacent said open end, said end cap including a number of passageways adapted to carry a heat transfer media, said heat transfer media flowing through said number of passageways in said end cap to effectuate heat transfer between said heat transfer media and said metallic melt disposed adjacent said end cap.

42. The apparatus of claim 33, wherein said temperature-controlled vessel includes a sidewall extending along an axis, said sidewall defining a passage for containing said metallic melt, said temperature-controlled vessel including a movable end wall displaceable along said passage to discharge said semi-solid material therefrom.

43. The apparatus of claim 42, wherein said sidewall and said movable end wall each include a number of passageways adapted to carry a heat transfer media, said heat transfer media flowing through said number of passageways in said sidewall and said end wall to effectuate heat transfer between said heat transfer media and said metallic melt.

44. The apparatus of claim 33, wherein said temperature-controlled vessel includes an inner containment vessel and an outer thermal jacket, said thermal jacket

defining at least one of said plurality of heat transfer zones and being positioned in close proximity to an outer surface of said containment vessel to effectuate heat transfer therebetween.

45. The apparatus of claim 44, wherein said heat transfer is conductive heat transfer.

46. The apparatus of claim 44, wherein said thermal jacket defines a plurality of heat transfer sections, one of said heat transfer sections being adapted to control the temperature of the metallic melt disposed adjacent a first axial portion of said containment vessel, another of said heat transfer sections being adapted to control the temperature of the metallic melt disposed adjacent a second axial portion of said containment vessel.

47. The apparatus of claim 46, wherein said thermal jacket includes a third heat transfer section adapted to control the temperature of the metallic melt disposed adjacent an end wall of said containment vessel.

48. The apparatus of claim 47, wherein said thermal jacket includes a forth heat transfer section adapted to control the temperature of the metallic melt disposed adjacent an open end of said containment vessel.

49. The apparatus of claim 44, wherein said thermal jacket substantially encapsulates said containment vessel.

50. A method of semi-solid forming a shaped article, comprising:

providing a metal alloy, a vessel and a mold;

heating the metal alloy to form a metallic melt;

transferring an amount of the metallic melt into the vessel;

nucleating the metallic melt by regulating the transferring of the metallic melt into the vessel; and

crystallizing the metallic melt in the vessel by cooling the metallic melt at a controlled rate to produce a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix;

feeding the semi-solid material from the vessel directly into the mold; and

forming the semi-solid material into a shaped article.

51. The method of claim 50, wherein the vessel comprises:

a passage for receiving the metallic melt; and

a ram displaceable along the passage, the feeding comprising injecting the semi-solid material directly into the mold by displacing the ram along the passage.

52. The method of claim 51, further comprising controlling the rate of displacement of the ram to provide non-turbulent flow of the semi-solid material into the mold.

53. The method of claim 52, wherein the rate of displacement of the ram is between about 1 inch per second and about 50 inches per second.

54. The method of claim 53, wherein the rate of displacement of the ram is between about 1 inch per second and about 10 inches per second.

55. The method of claim 50, wherein performance of the transferring, nucleating, crystallizing and feeding occur within a total cycle time of less than 60 seconds.

56. The method of claim 50, wherein performance of the nucleating, crystallizing and feeding occurs within a total cycle time of less than 45 seconds.

57. The method of claim 50, wherein performance of the nucleating and crystallizing occurs within a total cycle time of less than 30 seconds.

58. An apparatus for producing semi-solid material for semi-solid forming a shaped part, comprising:

a furnace adapted to heat a metal alloy to form a metallic melt; and

a temperature-controlled vessel, including:

a passage adapted to receive an amount of said metallic melt, said metallic melt being cooled at a controlled rate to cause said metallic melt to crystallize and form a semi-solid material having a microstructure comprising rounded solid particles dispersed in a liquid metal matrix; and

a ram displaceable along said passage to discharge said semi-solid material therefrom.

59. The apparatus of claim 58, wherein said semi-solid material is discharged directly into a die mold to form a shaped part.

60. The apparatus of claim 58, wherein the rate of displacement of said ram is controlled to provide non-turbulent flow of said semi-solid material into said mold.

61. The apparatus of claim 60, wherein the rate of displacement of said ram is between about 1 inch per second and about 10 inches per second.

62. The apparatus of claim 58, wherein said passage of said temperature-controlled vessel is bounded by a sidewall, the temperature of said sidewall being regulated to provide said controlled rate of cooling.

63. The apparatus of claim 62, wherein the temperature of said ram is regulated to provide said controlled rate of cooling.

64. The apparatus of claim 58, wherein said controlled rate of cooling is within a range of about 0.01 degrees Celsius per second to about 5.0 degrees Celsius per second.

65. The apparatus of claim 58, wherein said temperature-controlled vessel including a plurality of heat transfer zones, each of said plurality of heat transfer zones being adapted to independently control the temperature of the metallic melt disposed adjacent thereto.